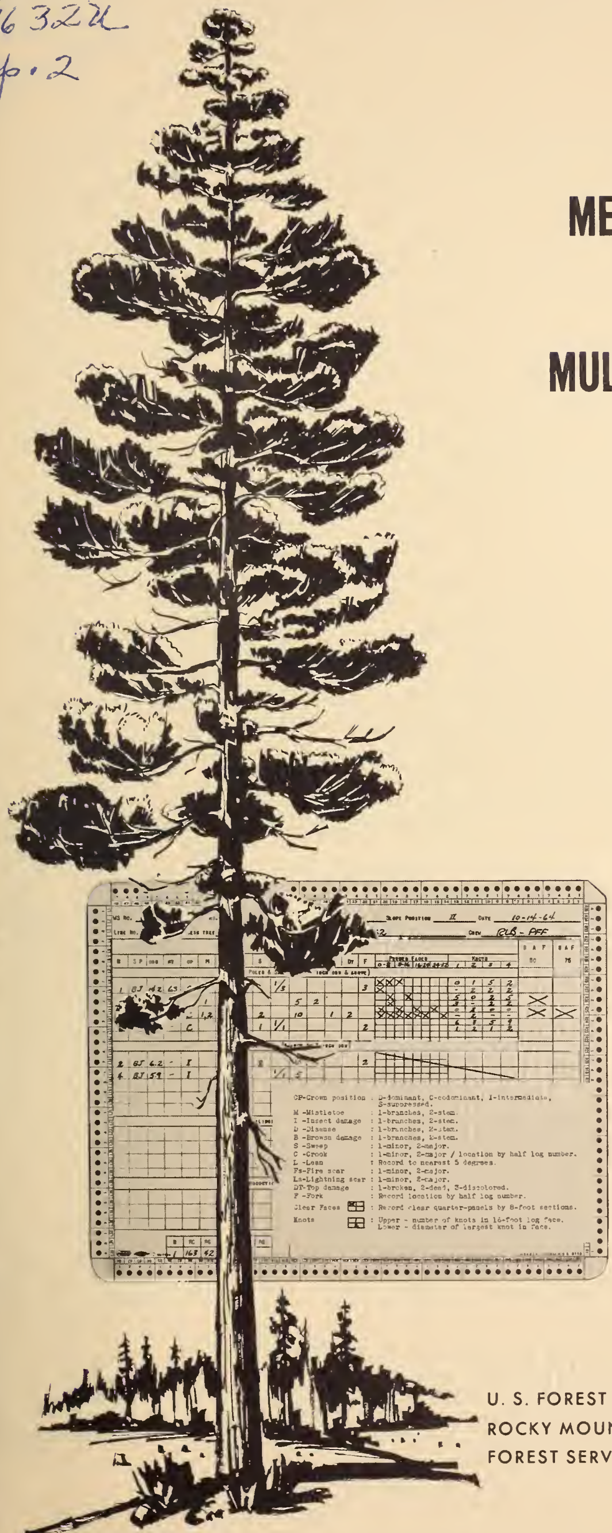


# A METHOD OF EVALUATING MULTIPRODUCT POTENTIAL IN STANDING TIMBER



U. S. FOREST SERVICE RESEARCH PAPER RM- 15, OCTOBER 1965
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## FOREWORD

This paper describes and illustrates a method for evaluating multiproduct potential in standing timber. The method described will:

1. Remove observer bias from stand quality inventory.
2. Provide a record of frequency of occurrence of stem features that affect product quality and yield.
3. Characterize and quantify suitability of the timber resource for a broad range of products.
4. Provide adequate multiproduct quality and yield information for management and utilization decisions.
5. Provide a continuing basis for such decisions through time.

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# A METHOD OF EVALUATING MULTIPRODUCT POTENTIAL IN STANDING TIMBER

by

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# A Method of Evaluating Multiproduct Potential in Standing Timber

by

Peter F. Ffolliott and Roland L. Barger

## INTRODUCTION

Patterns of forest utilization are changing rapidly, with added emphasis upon new products, new conversion methods, and broader product diversification. The diversity of feasible end products makes it difficult to estimate the overall product potential of standing timber. Quality information obtained by a specific product grading system is inadequate for multiproduct appraisal.

An inventory method is needed for evaluating the suitability of standing timber over the full range of potential primary products. Such a method must evaluate standing timber in terms other than the product specifications in immediate use. Many commercial product specifications are nonuniform and incomplete, and all are subject to revision and refinement. Frequent changes in product specifications emphasize the need for basic timber quality information, divorced from specific product grading systems, but easily adapted to new or revised systems. A method of quality appraisal must consequently depend upon recognizing the fundamental stem or stand characteristics affecting wood product yields and quality. With adequate knowledge of these characteristics, it is possible to estimate present and near-future product potential for a wide variety of products.

To be effective, a method of evaluating multiproduct potential in standing timber must be easily employed with a minimum need for observer interpretation. Instead of recording a specific product grade, the quality features[2] that in general determine product grades and yield should be measured. Then, the standing timber can be appraised by applying raw-material quality standards applicable to any product.

How detailed an inventory system is must necessarily be a compromise between information desired and time and effort required to get it. A workable inventory system cannot be encumbered with detail to the extent that it becomes difficult and time consuming to apply on the ground.

The purpose of this paper is to describe a method for evaluating multiproduct potential in standing timber, and to show how data reflecting the occurrence of features that affect product quality and yield are used to estimate multiproduct potential. Measurements made in a cutover southwestern ponderosa pine stand are used to illustrate the method. The basic methodology can be extended to other types and other areas.

## STUDY AREA

The study area is a 450-acre watershed on the Beaver Creek Watershed Evaluation Project in Arizona.[3] Ponderosa pine (Pinus ponderosa Laws.) comprises 85 percent of the cubic-foot volume on the area, with Gambel oak (Quercus gambelii Nutt.) and alligator juniper (Juniperus deppeana Steud.) as intermingling minor species. The soil on the area is of two soil management units, Siesta-

[2] *Quality features, as used here, are features that are correlated with suitability, yield, or both, for particular end uses.*

[3] *A 275,000-acre watershed on the Coconino National Forest in northern Arizona where costs and benefits of intensive multiple-use land management are being evaluated as a part of the Arizona Watershed Program.*

Sponseller, a "high"[4] timber producer, and Stoneman, a "medium"[4] timber producer. Timber was last cut on the study area from 1943 to 1950; one-half of the estimated merchantable volume of sawtimber was removed.

## METHODS OF DATA COLLECTION

### Sample Design

The method of collecting the needed data is based on point-sampling techniques. A system of point samples is placed on the ground to give a representative sample of the area, and trees are selected for measurement by using an angle gage or a prism. The occurrence of stem features that determine potential product quality and yield is then recorded for these trees.

The sample design for locating point samples may be systematic, or, if a measure of variation is desired, systematic with multiple random starts (Freese 1962, Shiue 1960).[5] If systematic sampling with multiple random starts is used, the point samples should be placed at regular intervals along lines that run across the major variation in the population. By considering each line of point samples as a sample unit, the variation will then be maximized within and minimized between sample units.

The sampling intensity will depend on (1) the variability in occurrence of the different stem features in the population, and (2) the degree of accuracy desired in sampling the features. The basal area factor (BAF) to be used in selecting individual trees for measurement will also depend on the degree of intensity desired in sampling the occurrence of stem features.

For this study, systematic sampling with multiple random starts was chosen (fig. 1). A regular interval of 3 chains (198 feet) was established between points of a system of 200 point samples. At each point sample, ponderosa pine 7.0 inches in diameter and larger were selected for measurement by using an angle gage with a basal area factor of 25.

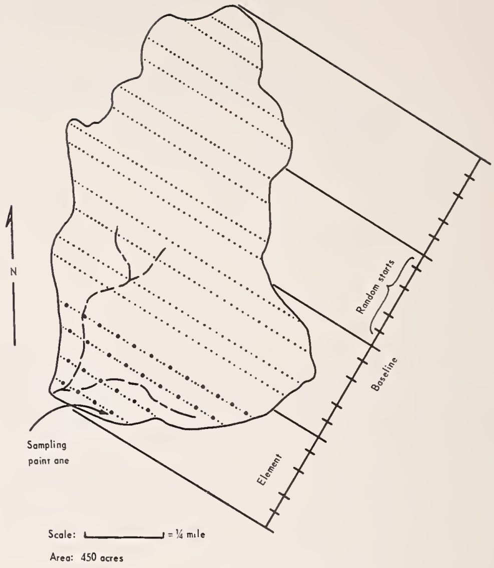


*Figure 1.--The study area and illustrative systematic sampling design based on multiple random starts. Sampling points are located at uniform intervals along each random start or line.*

### Individual Tree Measurements

For each sample tree, selected stem features affecting product quality and quantity were measured or observed. Tree species and d.b.h. were recorded for each tree. Total height was measured from a subsample of trees sufficient to form a basis for a d.b.h.-height curve. In addition, the merchantable height of potential commercial pole stems was measured.

Other stem quality features observed can be broadly classified as (1) stem form features, (2) injury features, and (3) log knot configurations. Outlined below are the specific measurements recorded for these features.

[4] *Terms used to describe soil management area timber potentials, in Anderson, T. C., Jr., Williams, J. A., and Crezee, D. B. Soil management report for Beaver Creek Watersheds of Coconino National Forest, Region 3. 66 pp., illus. 1960. (Mimeographed report on file at Region 3 office, U. S. Forest Serv., Albuquerque, N. Mex.)*

[5] *Names and dates in parentheses refer to Literature Cited, p. 24.*

## Form Features in the Merchantable Stem

1. Feature:

   Sweep

2. Definition:

   Gradual bend in merchantable stem (fig. 2)

3. Record:

   1 if less than 1/3 d.b.h. deviation in straightness

   2 if 1/3 d.b.h. or more deviation in straightness

*Figure 2.--Sweep in the merchantable stem affects suitability and yield for many end uses.*

*Figure 3.--Crook is a common grading and scaling defect.*

1. Feature:

   Crook

2. Definition:

   Abrupt bend in merchantable stem (fig. 3)

3. Record:

   1 if less than 1/2 mean diameter deviation in straightness within a section 5 feet or less in length

   2 if 1/2 mean diameter or more deviation in straightness within section 5 feet or less in length

   NUMBER of half-log in which a crook occurs

1. Feature:

    Lean

2. Definition:

    Deviation of straight stem from vertical (fig. 4)

3. Record:

    DEGREE, to nearest 5-degree increment. Measure with plumb-bob device (Marden and Conover (1959) (fig. 5)

*Figure 4.--Leaning stems develop compression wood, a limiting defect for many end uses.*

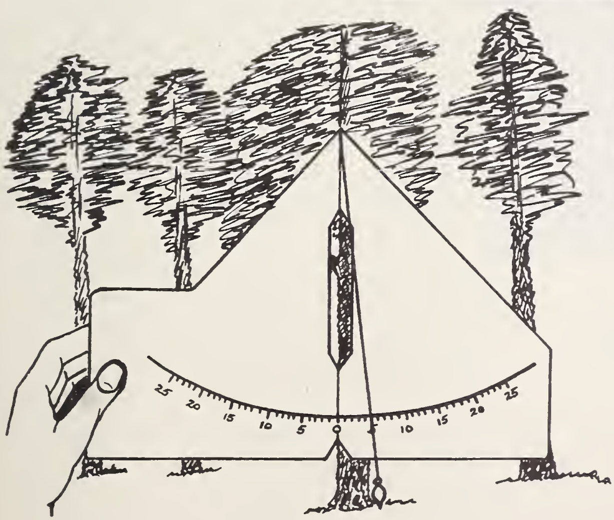


*Figure 5.--A plumb-bob device was used to determine degree of stem lean.*

*Figure 6.--Fork in the merchantable stem affects both yield and grade.*

1. Feature:

   Fork

2. Definition:

   Point of division of the merchantable stem (fig. 6)

3. Record:

   NUMBER of half-log in which fork occurs

## Injury Features in the Merchantable Stem

1. Feature:

    Scar (fire, lightning, etc.)

2. Definition:

    Opening in bark exposing underlying wood (figs. 7, 8, and 9)

3. Record:

    1 if less than 1/4 circumference of stem affected

    2 if 1/4 circumference or more of stem affected

*Figure 7.--Fire scars may affect one or more faces of the merchantable stem.*

*Figure 8.--Many lightning strikes cause only superficial physical damage to the merchantable stem (left). Occurrence of this type of scar was not recorded.*

*Figure 9.--Severe lightning scars and associated fire damage may warrant extensive grade and yield reductions (right). Occurrence of this type of scar was recorded.*

1. Feature:

   Internal rot

2. Definition:

   Fungi causing partial decomposition of the merchantable stem

3. Record:

   OCCURRENCE of rot in increment borings taken from first tree tallied at each sample point (fig. 10)

*Figure 10.--Full-length increment cores were removed from selected sample trees and then examined for indications of internal rot.*

## Log Knot Configurations in the Merchantable Stem

NOTE: Both occurrence and distribution of log knots are important indicators of product potential. Accordingly, knot features of butt logs were characterized first by occurrence of half-faces clear of knots, secondly by number and size of knots; second logs by occurrence of clear half-faces only.

1. Feature:

   Clear face

2. Definition:

   Section of stem free of log knots (fig. 11)

3. Record:

   NUMBER and POSITION of clear 8-foot half-faces in the merchantable stem (panels 8 feet × 1/4 stem circumference) selected by following procedure:

   Select a clear 8-foot half-face in butt 8-foot section of merchantable stem, and designate as face number one. If no clear half-face exists, arbitrarily select face number one.

   Record number of clear 8-foot half-faces in butt section, tallying in clockwise direction from face one.

   Record number of clear 8-foot half-faces in second 8-foot section of merchantable stem, following the same procedure, with "face one" directly alined above butt "face one."

   Follow procedure through four 8-foot sections, or to 10-inch top diameter, whichever occurs first.

   Use same designated log face positions as basis for knot count (see next page).

*Figure 11.--Clear log faces may determine suitability for many uses.*

1. Feature:

   Log knots

2. Definition:

   Live or dead limbs, stubs, indicators, and overgrowths (Jackson 1962).

3. Record:

For sawtimber:

NUMBER of knots in each face of butt 16-foot log.

SIZE of largest knot in each face.

For commercial poles:[6]

NUMBER of log knots in each face of full merchantable length.

SIZE of largest knot in each pole face.

The stem quality features observed are those believed most indicative of suitability and yield for a wide range of products. There are many other factors that can be important in determining material quality. Perhaps the major quality feature omitted from the described system is density, or specific gravity. Specific gravity is recognized as the best single index to the suitability of wood for several end uses; where it is of prime interest, or is subject to question, it can easily be included as an observed feature in the inventory system. Increment cores taken from selected trees at each sampling point will provide a ready basis for determining tree specific gravity averages and variation.

## OCCURRENCE OF STEM QUALITY FEATURES IN A STAND

Recorded stem quality information can easily be aggregated to show the frequency of occurrence of any particular feature in the sampled stand or area, a prerequisite to further analysis of product potential for the stand. The frequency of occurrence information presented herein illustrates development of occurrence data for an area.

A stand table representative of the study area was developed from all trees tallied on the 200 point samples. Stand tables were similarly developed for trees exhibiting specific stem form or injury features. By comparing stand tables, the frequency of occurrence of specific stem features was determined.

Log knots and clear log half-faces are features potentially common to all stems, and consequently cannot be described by the stand table method. Their occurrence is instead expressed as percent of stems having specific knot size and number and/or clear half-face characteristics.

### Form Features In The Merchantable Stem

Irregular form features in the merchantable stems of standing timber can substantially influence product potential. Sweep, crook, lean, and fork are particularly important determinants of volume and quality of timber for specific end uses or products (table 1).

For example, sweep reduces the usable volume of sawtimber stems, and limits the use of stems as poles. Sweep may not lower recovery from pulpwood stems, but does reduce the amount of solid wood per cord.

The suitability of standing timber for different products can be reduced as a result of crook. Crook may lower the net volume in a merchantable stem, or may be a limiting feature, as in commercial poles.

Lean is common in standing timber, and because leaning boles develop reaction wood,[7] lean is an important form characteristic. Compression wood in coniferous species is usually considered present in stems with 5 degrees of lean or more (Pillow and Luxford 1937).

[6] *Well-formed stems 9.0 to 18.9 inches in d.b.h. are considered potential commercial poles if merchantable length in feet is at least 2-1/2 times d.b.h. in inches. Merchantable length is limited by (1) length to major crown, or (2) length to single log knot 4 inches or more in diameter, or (3) length to first occurrence of knots aggregating 8 inches in diameter within a 1-foot section.*

[7] *Reaction wood is abnormal wood found in leaning stems, and is commonly referred to as compression wood in softwoods and tension wood in hardwoods.*

Table 1.--Percentage of occurrence of stem-quality features, by size classes and number of trees per acre on the study area

| Stem-quality features | | Size class by diameter breast height (inches) | | | | | | | | | | | | | | | | All size classes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | |
| FORM FEATURES-- | | Percent | | | | | | | | | | | | | | | | |
| Sweep: | | | | | | | | | | | | | | | | | | |
| Minor[1] | | 11 | 9 | 15 | 20 | 10 | 13 | 7 | 6 | 7 | 8 | 19 | 11 | 0 | 0 | 0 | 0 | 11.2 |
| Major[2] | | 3 | 2 | 0 | 0 | 5 | 9 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 2.1 |
| Total | | 14 | 11 | 15 | 20 | 15 | 22 | 7 | 6 | 7 | 12 | 19 | 11 | 0 | 0 | 0 | 0 | 13.3 |
| Crook, by 8-ft. stem sections: | | | | | | | | | | | | | | | | | | |
| Minor[3] | First | 5 | 6 | 8 | 5 | 5 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5.1 |
| | Second | 3 | 4 | 0 | 0 | 5 | 4 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.7 |
| | Third | 5 | 2 | 6 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.6 |
| | Fourth | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .1 |
| | Over four | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .1 |
| | Total | 13 | 12 | 14 | 5 | 10 | 8 | 8 | 6 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11.6 |
| Major[4] | First | 1 | 0 | 4 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.4 |
| | Second | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Third | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .2 |
| | Fourth | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Over four | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | .1 |
| | Total | 1 | 0 | 4 | 10 | 5 | 0 | 0 | 0 | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1.7 |
| Total | | 14 | 12 | 18 | 15 | 15 | 8 | 8 | 6 | 6 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 13.3 |
| Lean: | | | | | | | | | | | | | | | | | | |
| 5 degrees | | 8 | 11 | 8 | 5 | 15 | 22 | 27 | 27 | 21 | 24 | 53 | 0 | 100 | 0 | 0 | 0 | 10.8 |
| 10 degrees | | 1 | 0 | 0 | 5 | 20 | 6 | 4 | 9 | 10 | 4 | 9 | 0 | 0 | 0 | 0 | 0 | 2.2 |
| 15 degrees | | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 3 | 0 | 4 | 9 | 0 | 0 | 0 | 0 | 0 | .4 |
| 20 degrees | | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .3 |
| Total | | 9 | 11 | 10 | 10 | 35 | 28 | 38 | 39 | 31 | 32 | 71 | 0 | 100 | 0 | 0 | 0 | 13.7 |
| Fork, by 8-ft. stem sections: | | | | | | | | | | | | | | | | | | |
| First | | 3 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.5 |
| Second | | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .1 |
| Third | | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .1 |
| Fourth | | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .1 |
| Fifth | | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .1 |
| Sixth | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | .1 |
| Seventh | | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | .1 |
| Total | | 3 | 0 | 0 | 0 | 5 | 6 | 12 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 2.1 |
| INJURY FEATURES-- | | | | | | | | | | | | | | | | | | |
| Fire scar: | | | | | | | | | | | | | | | | | | |
| Minor[5] | | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 67 | .2 |
| Major[6] | | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 3 | 0 | 0 | 11 | 0 | 50 | 0 | 0 | .2 |
| Total | | 0 | 0 | 0 | 0 | 0 | 3 | 4 | 3 | 3 | 0 | 0 | 11 | 0 | 50 | 0 | 67 | .4 |
| Lightning scar: | | | | | | | | | | | | | | | | | | |
| Minor[5] | | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 6 | 3 | 4 | 19 | 0 | 0 | 0 | 0 | 0 | .5 |
| Major[6] | | 0 | 0 | 0 | 0 | 0 | 3 | 7 | 6 | 10 | 12 | 9 | 11 | 0 | 50 | 0 | 67 | 1.0 |
| Total | | 0 | 0 | 0 | 0 | 0 | 3 | 11 | 12 | 13 | 16 | 28 | 11 | 0 | 50 | 0 | 67 | 1.5 |
| | | Number | | | | | | | | | | | | | | | | |
| TREES PER ACRE -- | | 28.2 | 12.4 | 7.62 | 2.36 | 1.80 | 2.25 | 1.48 | 1.61 | 1.16 | 0.82 | 0.32 | 0.18 | 0.02 | 0.04 | 0.02 | 0.03 | 60.31 |

[1] Less than one-third d.b.h. deviation in straightness.
[2] At least one-third d.b.h. deviation in straightness.
[3] Less than one-half mean diameter deviation in straightness within section 5 feet or less in length.
[4] At least one-half mean diameter deviation in straightness within section 5 feet or less in length.
[5] Affecting less than one-fourth merchantable stem circumference.
[6] Affecting at least one-fourth merchantable stem circumference.

Forking in the merchantable stem limits the length or net scale of products obtained. The distorted grain accompanying a fork may also lower the quality of adjacent material.

## Injury Features In The Merchantable Stem

The presence of mechanical injuries such as fire and lightning scars [8] (table 1) can reduce substantially the usable volume of standing timber. Injury scars are also recognized as secondary grading defects in determining timber quality for various products.

Internal rot in the merchantable stem is often the greatest single cause of biological injury in a forest (Pearson 1950). Internal rot can greatly reduce the yield of material suitable for different products.

Evidence of heart rot in increment cores should be used as an index of occurrence and not necessarily as an absolute measure of incidence and cull volume. Heart rot [9] was ob-

[8] *Occurrence of superficial lightning scars was not recorded; only those sufficiently severe to affect the yield and/or grade of material were recorded (see figs. 8 and 9).*

[9] *Polyporus anceps Pk. (P. ellisianus (Murr.) Sacc. & Trott.) is common heart rot in ponderosa pine in the Southwest (Andrews 1955).*

Table 2.--Occurrence of clear half-faces[1] in the first two 8-foot stem sections[2] and of log knots in the butt 16-foot logs of the sawtimber on the study area

| Configurations in merchantable stem | Size class by diameter breast height (inches) | | | | | | | | | | | | | | All size classes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | |
| | Percent of stems | | | | | | | | | | | | | | |
| Clear half-faces in first and second 8-foot sections: | | | | | | | | | | | | | | | |
| None -- | | | | | | | | | | | | | | | |
| First | 100 | 95 | 74 | 80 | 68 | 68 | 75 | 68 | 73 | 50 | 50 | 0 | 0 | 50 | 77.5 |
| Second | 100 | 100 | 90 | 94 | 80 | 88 | 100 | 84 | 91 | 100 | 100 | 100 | 100 | 0 | 92.1 |
| One -- | | | | | | | | | | | | | | | |
| First | 0 | 0 | 21 | 10 | 20 | 26 | 14 | 16 | 27 | 50 | 50 | 100 | 0 | 0 | 15.0 |
| Second | 0 | 0 | 10 | 3 | 20 | 6 | 0 | 12 | 9 | 0 | 0 | 0 | 0 | 100 | 6.3 |
| Two; opposite -- | | | | | | | | | | | | | | | |
| First | 0 | 0 | 5 | 3 | 0 | 3 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 50 | 2.4 |
| Second | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Two or more; adjacent -- | | | | | | | | | | | | | | | |
| First | 0 | 5 | 0 | 7 | 12 | 3 | 7 | 12 | 0 | 0 | 0 | 0 | 100 | 0 | 5.1 |
| Second | 0 | 0 | 0 | 3 | 0 | 6 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1.6 |
| Log knots in butt 16-foot logs: | | | | | | | | | | | | | | | |
| Number -- | | | | | | | | | | | | | | | |
| 0 - 10 | 0 | 0 | 0 | 10 | 4 | 15 | 3 | 0 | 9 | 33 | 0 | 50 | 0 | 50 | 5.9 |
| 11 - 20 | 8 | 5 | 26 | 10 | 36 | 21 | 29 | 56 | 28 | 17 | 50 | 50 | 0 | 50 | 23.3 |
| 21 - 30 | 17 | 25 | 42 | 53 | 28 | 32 | 39 | 20 | 45 | 33 | 50 | 0 | 0 | 0 | 30.4 |
| Over 30 | 75 | 70 | 32 | 27 | 32 | 32 | 29 | 24 | 18 | 17 | 0 | 0 | 100 | 0 | 40.4 |
| Size of largest knot -- | | | | | | | | | | | | | | | |
| 1 - 2 inches | 33 | 35 | 26 | 20 | 12 | 12 | 3 | 12 | 0 | 17 | 0 | 0 | 0 | 0 | 18.2 |
| 3 - 4 inches | 65 | 55 | 63 | 64 | 64 | 53 | 68 | 60 | 36 | 17 | 50 | 50 | 0 | 100 | 59.6 |
| 5 - 6 inches | 2 | 5 | 11 | 13 | 24 | 32 | 29 | 28 | 36 | 66 | 50 | 50 | 0 | 0 | 19.8 |
| Over 6 inches | 0 | 5 | 0 | 3 | 0 | 3 | 0 | 0 | 28 | 0 | 0 | 0 | 100 | 0 | 2.4 |
| | Number | | | | | | | | | | | | | | |
| Trees on study area | 48 | 20 | 19 | 30 | 25 | 34 | 28 | 25 | 11 | 6 | 2 | 2 | 1 | 2 | 253 |

[1] Log surface one-fourth the circumference of the log and 8 feet in length.
[2] Occurrence of clear 8-foot half-faces was recorded for entire merchantable stem; data are not presented for stem sections above 16 feet, since they contained less than 2 percent of all clear-half-faces recorded.

served in 7 of 148 increment borings (4.7 percent) taken in ponderosa pine 8 inches d.b.h. and larger on the study area.

### Log Knot Configurations In The Merchantable Stem

Data on distribution of clear 8-foot half-faces and the number and size of log knots by tree size classes within the stand will allow an evaluation of standing timber potential for a variety of products.

Data on clear 8-foot half-faces, given in table 2, are for only the first two 8-foot stem sections, since they contained more than 98 percent of all clear half-faces recorded.

The occurrence and size of log knots in the butt 16-foot log are shown in table 2. The same data would be shown to describe the occurrence and size of log knots in potential poles if stems meeting commercial requirements (see footnote 6) were available.

## INTERPRETATION OF STEM QUALITY INFORMATION

The recorded stem-quality data have wide potential application in characterizing either a stem or a stand. The data allow a wide range of interpretive precision, depending upon the nature of quality information desired. Many management and utilization decisions can be based upon a broad analysis of the quality and product potential of a stand. This type of analysis may require only consideration of certain stem quality features in the aggregate; that is, in terms of frequency of occurrence in the stand as a whole. Conversely particular utilization decisions may require a quite detailed analysis of stem features in specific size or form classes. Finally, detailed inquiries may warrant diagraming individual sample stems. The degree of precision in interpretation can be tailored somewhat to meet the needs at hand.

The wide range of stem quality information afforded by the data is best illustrated through schematic diagraming techniques. The butt logs of the first four trees recorded in figure 12 are diagramed in figures 13 through 16. In addition, the full merchantable pole length of tree number 4 is diagramed in figure 16.

As is apparent in the preceding diagrams, rather definite quality inferences for a variety of products can be drawn from the stem quality data. Such quality information for a

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Slope Posit Intermed. Slope Percent 5 Crew PF-RB

| No | SP | DBH | HT | S | C | L | Fs | Ls | F | Clear faces 8 | 16 | 24 | 32 | Knots 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Large Poles & Sawtimber (8" DBH and over) | | | | | | | | | | | | | | | | | |
| 1 | PP | 21.3 | 63 | | | 5 | 2 | | | X | X | | | 0 / – | 6 / 3 | 9 / 3 | 2 / 2 |
| 2 | PP | 18.2 | | | 1/1 | 5 | | | 2 | X | | | | 9 / 2 | 17 / 2 | 12 / 3 | 14 / 2 |
| 3 | PP | 35.8 | | 2 | | 10 | 1 | | | X | X | | | 3 / 4 | 8 / 4 | 5 / 6 | 7 / 5 |
| 4 | PP | 13.8 | | | 1/3 | | | | | | | | | 9 / 2 | 11 / 1 | 12 / 2 | 10 / 1 |
| " (AS | " POLE) | " | POLE HT. 35' | | 1/3 | | | | | | | | | 17 / 2 | 23 / 2 | 21 / 3 | 18 / 2 |
| Small Poles (4 to 7-inch DBH) | | | | | | | | | | | | | | | | | |
| 5 | PP | 6.2 | | 2 | | 10 | | | 2 | | | | | | | | |
| 6 | PP | 5.9 | | | 1/1 | 5 | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

Key to recorded stem features:

S - Sweep : 1 indicates minor, 2 indicates major.

C - Crook : 1 above slash indicates minor, 2 indicates major; number below slash indicates half-log height in tree.

L - Lean : Recorded in degrees, to the nearest 5-degree increment.

Fs - Fire scar : 1 indicates minor, 2 indicates major.

Ls - Lightning scar : 1 indicates minor, 2 indicates major.

F - Fork : Number indicates half-log height of occurrence in tree

Clear Faces : Occurrence of 8-foot clear panels indicated by position on stem, for first 32 feet of merchantable height.

Knots : For each face of butt 16-foot log, upper number indicates total knots in face, lower number indicates diameter of largest knot

*Figure 12.--Sample tally card for a single sampling point, indicating manner in which stem quality information was recorded.*

RECORDED QUALITY FEATURES FROM THE INVENTORY RECORD CARD, SUCH AS:

| N | SP | DBH | S | C | L | Fs | Ls | F | CLEAR FACES 8 | 16 | 24 | 32 | KNOTS 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PP | 21.3 | | | 5 | 2 | | | X | X | | | 0 | 6 | 9 | 2 |
| | | | | | | | | | | | | | – | 3 | 3 | 2 |

CAN BE DIAGRAMED AS:

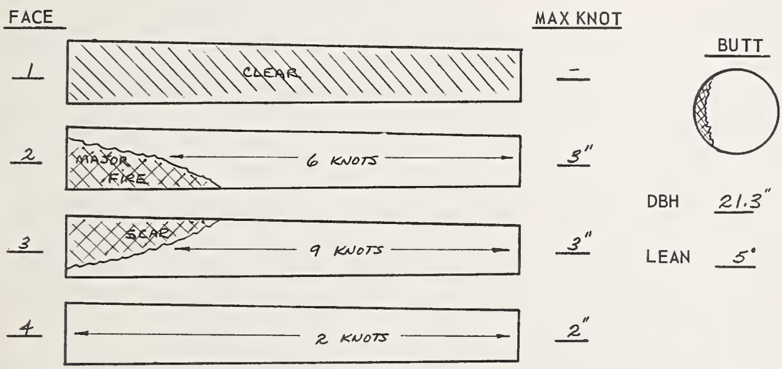


*Figure 13.--Schematic diagram of features of the butt 16-foot log--tree number 1.*

RECORDED QUALITY FEATURES FROM THE INVENTORY RECORD CARD, SUCH AS:

| N | SP | DBH | S | C | L | Fs | Ls | F | CLEAR FACES 8 | 16 | 24 | 32 | KNOTS 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | PP | 18.2 | | 1/1 | 5 | | | 2 | X | | | | 9 | 17 | 12 | 14 |
| | | | | | | | | | | | | | 2 | 2 | 3 | 2 |

CAN BE DIAGRAMED AS:

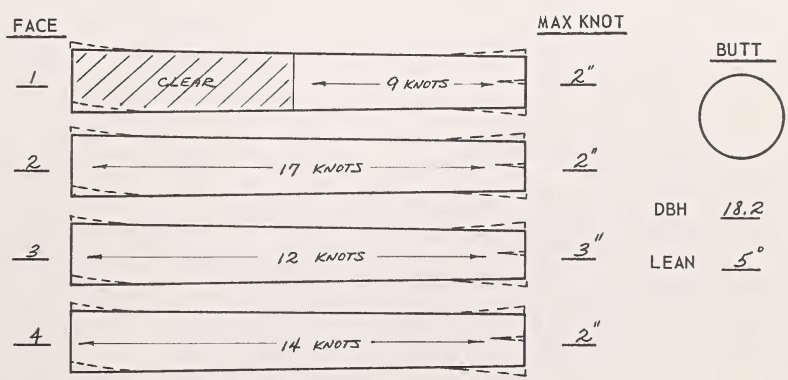


*Figure 14.--Schematic diagram of features of the butt 16-foot log--tree number 2.*

RECORDED QUALITY FEATURES FROM THE INVENTORY CARD, SUCH AS:

| N | SP | DBH | | S | C | L | Fs | Ls | | F | CLEAR FACES 8 | 16 | 24 | 32 | KNOTS 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | PP | 35.8 | | 2 | | 10 | 1 | | | | X | X | | | 3 / 4 | 8 / 4 | 5 / 6 | 7 / 5 |

CAN BE DIAGRAMED AS:

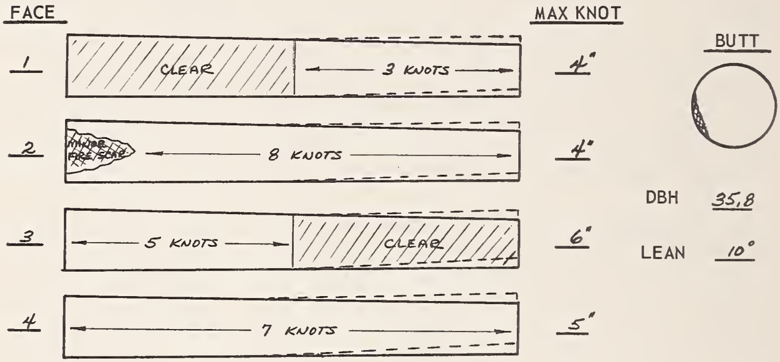


*Figure 15.--Schematic diagram of features of the butt 16-foot log--tree number 3.*

RECORDED QUALITY FEATURES FROM STEMS HAVING APPARENT POTENTIAL FOR COMMERCIAL POLES, SUCH AS:

| N | SP | DBH | HT | | S | C | L | Fs | Ls | | F | CLEAR FACES 8 | 16 | 24 | 32 | KNOTS 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | PP | 13.8 | 52 | | | 1/3 | | | | | | | | | | 9 / 2 | 11 / 1 | 12 / 2 | 10 / 1 |
| " (AS POLE) | " | " | POLE HT. 35 | | | " | | | | | | | | | | 17 / 2 | 23 / 2 | 21 / 3 | 18 / 2 |

WILL PERMIT DIAGRAMING FULL POTENTIAL POLE LENGTH, AS:

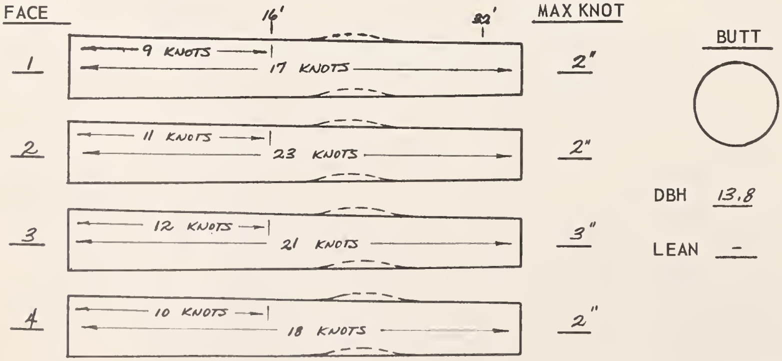


*Figure 16.--Schematic diagram of features of the butt 16-foot log, and merchantable pole length, of tree number 4.*

stand provides the basis for appraising and comparing potential for products considered either now or later. The range of products under consideration will vary somewhat with the locale and nature of the timber.

## MULTIPRODUCT POTENTIAL-- AN EXAMPLE

The inventory system described provides a means of appraising the potential of a timber stand for a range of products. Gross and net volumes of raw material, by size class, can be determined. The extent and impact of particular types of visible defect important to specific products can be appraised. More important, the material can be stratified into quality classes or grades appropriate for the products considered. The following analysis of multiproduct potential on the study area is presented as an example of application of the system to a specific timber stand.

For the locale and the timber under study, four primary products were considered: saw logs, veneer logs, commercial poles, and pulpwood. Although local markets are not currently active for all these products, their development in the foreseeable future seems imminent. The manner in which recorded quality data can be applied in appraising product potential is amply demonstrated by this group of products.

### Saw Log Potential

#### Gross Volume Determination

All timber in diameter classes 12 inches and larger was considered potential sawtimber. Gross volume, by diameter class, was obtained by applying localized board-foot Scribner scale volume tables (Myers 1963) to stand measurement data. A high proportion of the merchantable volume of sawtimber was found in butt 16-foot logs. All diameter classes averaged less than two full logs in merchantable height. The gross volume in each diameter class, and the proportion of volume by log position, are shown in table 3.

Table 3. --Gross volume,[1] deductions by defect type, and net volume[2] of saw logs by tree diameter class

| D.b.h. class (Inches) | Gross saw-log volume | | | | | Deduction by defect type | | | | | | | Net saw-log volume | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Per acre | Distribution by log position | | | | Fire scar | Lightning scar | Fork | Crook | Minor sweep[3] | Major sweep[4] | Total defect | Per acre | Quality distribution by grade[5] | | | |
| | | Butt log | | Second log | | | | | | | | | | 3 and better | | 4 and 5 | |
| | Bd.ft. | Bd.ft. | Pct. | Bd.ft. | Pct. | Percent | | | | | | | Bd.ft. | Bd.ft. | Pct. | Bd.ft. | Pct. |
| 12 | 213 | 213 | 100 | 0 | 0 | 0 | 0 | 0 | 3.0 | 3.0 | 0 | 6.0 | 200 | 4 | 2 | 196 | 98 |
| 14 | 187 | 187 | 100 | 0 | 0 | 0 | 0 | 0 | 3.7 | 4.0 | 0 | 7.7 | 173 | 9 | 5 | 164 | 95 |
| 16 | 203 | 168 | 83 | 35 | 17 | 0 | 0 | .2 | 2.3 | 2.0 | 2.5 | 7.0 | 189 | 26 | 14 | 163 | 86 |
| 18 | 391 | 301 | 77 | 90 | 23 | .2 | 1.5 | 1.2 | 1.5 | 2.6 | 4.5 | 11.5 | 346 | 24 | 7 | 322 | 93 |
| 20 | 451 | 316 | 70 | 135 | 30 | 0 | 4.5 | .3 | 1.0 | 1.4 | 0 | 7.2 | 419 | 84 | 20 | 335 | 80 |
| 22 | 612 | 416 | 68 | 196 | 32 | 0 | 4.5 | 0 | .8 | 1.2 | 0 | 6.5 | 572 | 103 | 18 | 469 | 82 |
| 24 | 576 | 369 | 64 | 207 | 36 | .2 | 5.8 | 0 | .3 | 1.4 | 0 | 7.7 | 532 | 64 | 12 | 468 | 88 |
| 26 | 374 | 239 | 64 | 135 | 36 | 0 | 7.0 | 0 | 0 | 1.6 | 2.0 | 10.6 | 334 | 57 | 17 | 277 | 83 |
| 28 | 441 | 282 | 64 | 159 | 36 | 0 | 9.3 | 0 | 0 | 3.8 | 0 | 13.1 | 383 | 46 | 12 | 337 | 88 |
| 30 | 136 | 87 | 64 | 49 | 36 | .6 | 5.5 | 0 | 0 | 2.2 | 0 | 8.3 | 125 | 27 | 22 | 98 | 78 |
| 32 | 59 | 37 | 62 | 22 | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 59 | 19 | 33 | 40 | 67 |
| 34 | 34 | 21 | 62 | 13 | 38 | 2.6 | 25.0 | 0 | 0 | 0 | 0 | 27.6 | 25 | 17 | 67 | 8 | 33 |
| 36 | 26 | 16 | 60 | 10 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 17 | 67 | 9 | 33 |
| 38 | 42 | 27 | 64 | 15 | 36 | 0 | 33.3 | 0 | 0 | 0 | 0 | 33.3 | 28 | 19 | 67 | 9 | 33 |
| All size classes | 3,745 | 2,679 | 72 | 1,066 | 28 | .1 | 4.9 | .2 | .9 | 2.0 | .8 | 8.9 | 3,411 | 516 | 15 | 2,895 | 85 |

[1] Basis: Myers (1963).
[2] Exclusive of volume deduction due to internal defect.
[3] Less than one-third d.b.h. deviation in straightness.
[4] At least one-third d.b.h. deviation in straightness.
[5] Basis: Gaines (1962).

Net Volume Determination

Determining net volume of raw material for a particular product depends upon knowing (1) what stem features will reduce usable volume, (2) the frequency of occurrence of these features in a stand, and (3) the effect of these defect features upon the volume of a right cylinder or scaling cylinder.

For the stand considered, internal rot, scar, sweep, crook, and fork are stem features that may potentially reduce usable saw-log volume. Internal rot cannot be adequately evaluated in standing timber, except in terms of historical scaling data from similar stands. All other stem features mentioned are visible in standing timber, however, and can be evaluated. The frequency of occurrence of these features in the stand is known. The effect of a particular type of defect upon the volume of a right cylinder can be estimated. Frequency of occurrence data for a feature, when combined with estimated effect upon right cylinder volume, provides an index of scale deduction for that feature.

Theoretical determination of the effect of a particular type of defect upon scaling volume is subject to error. It should be noted, however, that only the effect of the defect upon volume of a right cylinder is estimated. This purely geometrical relationship can then be applied to known gross scale and known frequency of occurrence to calculate actual scaling deduction. This procedure should prove substantially more accurate than the common tree measurement scaling practice of applying a single predetermined cull factor to gross scale. In addition, a specific scale deduction by type of defect, for each diameter class, is estimated. This type of information is valuable as a further basis for utilization and management decisions.

Log diagrams and standard scaling procedures were used in determining the extent to which specific types of defect impinged upon the right cylinder. The scale-deduction factors used for visible defect were:

Scars--
- Fire scars
  - Minor fire scar--disregarded due to containment in the portion of stem lying outside a right cylinder.
  - Major fire scar--deduct 1/3 of lower 4 feet of the scaling cylinder; i.e.,1/12 of butt log gross scale.
- Lightning scars
  - Minor lightning scar--deduct 1/4 of gross scale of entire merchantable stem.
  - Major lightning scar--deduct 1/2 of gross scale of entire merchantable stem.

Fork--Deduct 1/4 of gross scale of the 16-foot log in which fork occurs.

Crook--Deduct 1/4 of gross scale of the log in which crook occurs.

Sweep[10]--
- Minor sweep--deduct 1/5 of gross scale of entire merchantable stem.
- Major sweep--deduct 1/2 of gross scale of entire merchantable stem.

In each diameter class, frequency of occurrence data were applied to gross scale, by log position, to obtain the actual volumes of timber affected by a particular defect. The appropriate scale deduction factor was then applied to the affected volume to determine board-foot scale deduction. Scaling deductions for each type of visible defect, by tree diameter classes, are shown in table 3. The resulting net volumes, exclusive of internal defect deductions, are also shown.

Saw-Log Quality Determination

In appraising saw-log quality potential, it is usually desirable to estimate log-grade distribution by the particular grading system currently recognized for the species. Saw-log grading systems are generally based upon the size, number, and distribution of log knots, the presence of clear surface area, and the occurrence of certain form and injury "secondary" defect. From the quality data reflecting the occurrence of these features,

[10] *Deductions for minor and major sweep are based upon sweep equal to 1/3 d.b.h. and full d.b.h., respectively, in 2-log trees.*

probable log-grade distribution in the stand can be ascertained with a high degree of confidence. Stratification into individual grades is not always necessary. For many utilization and management decisions, knowledge that a certain proportion of a stand of sawtimber will run "Grade 3 and better" and a remaining proportion "Grade 4 and lower" is invaluable. This type of information, as well as more detailed probable grade distribution, is readily obtained from the stem quality data.

The improved 5-grade log-grading system (Gaines 1962) is currently recognized for ponderosa pine. Accordingly, net saw-log volume was stratified by interpreting recorded stem quality data in terms of these specific grading rules. It was immediately apparent that the saw-log potential of the stand consisted primarily of Grade 5 material, with a small proportion of Grade 3 and better. In view of the inherently low quality spread, saw-log quality stratification into "Grade 3 and better" and "Grade 4 and lower" classes, by tree diameter class, appeared to be sufficiently detailed for practical purposes.

Logs were stratified into the two log-quality classes by applying the following grading criteria to recorded stem quality data: [11]

Butt logs--
- Grade 3 and better indicated by
  - Presence of 6 or more clear 4-foot surface panels.
  - Presence of 4 or 5 clear 4-foot surface panels, plus total of less than 25 log knots.
  - Presence of 2 or 3 clear 4-foot surface panels, plus total of less than 15 log knots.
- Remainder of butt logs considered Grade 4 or lower.

Second logs--Graded solely on the basis of presence or absence of clear surface area, adjusted for length of log.

[11] *To fit this particular grading system, presence of assured clear 4-foot panels may be indicated by recorded 8-foot clear half-faces (two panels), and by number of knots in a log face. For example, 2 log knots in a 16-foot log face assure at least 1 clear 4-foot panel.*

Net saw-log potential per acre, by log quality class and tree diameter class, is presented in table 3.

## Veneer Log Potential

### Gross Volume Determination

Gross veneer log potential, expressed in board feet Scribner scale, was considered equivalent to previously determined saw-log gross volume in the stand. Any stem of saw-log size is potentially veneer stock for sheathing-grade softwood plywood. Gross veneer log volume in each diameter class, and proportion of volume by bolt position, is shown in table 4.

### Net Volume Determination

Visible stem features that reduce usable veneer log volume differ somewhat from those affecting saw-log volume. They include scar, fork, crook, and lean. Most sweep can be eliminated in bucking to veneer-bolt lengths. For scar, fork, and crook, the scale deduction factors previously developed for saw logs were used. Because the compression wood found in leaning stems can seriously limit the manufacture of veneer, stems with a lean of 10 degrees or more were culled, and 100 percent of their volume deducted from gross volume. Net veneer log scale was obtained by applying these scale deduction factors in the manner previously discussed. Veneer log scale deductions for each type of visible defect, by tree diameter class, are shown in table 4. Net volumes, exclusive of deduction for internal defect, are also shown.

### Veneer Log Quality Determination

Well-defined quality standards do not exist for ponderosa pine veneer logs, yet some knowledge of the suitability of the timber for veneer is absolutely necessary for a rational appraisal of plywood opportunities. Quality standards that are developed for veneer logs will undoubtedly use as primary grading criteria some of the stem features included in this inventory system. Veneer recovery stud-

Table 4.--Gross volume,[1] deductions by defect type, and net volume[2] of veneer logs by tree diameter class

| D.b.h. class (Inches) | Gross veneer log volume | | | | Deduction by defect type | | | | | | Net veneer log volume | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Per acre | Distribution by veneer bolt position[3] | | | Fire scar | Lightning scar | Fork | Crook | Lean (10° or more) | Total defect | Per acre | Veneer log distribution by quality class[4] | | | | | |
| | | First | Second | Third | | | | | | | | Quality 1 | | Quality 2 | | Quality 3 | |
| | Bd.ft. | - - Percent - - | | | - - - - - - - Percent - - - - - - - | | | | | | Bd.ft. | Bd.ft. | Pct. | Bd.ft. | Pct. | Bd.ft. | Pct. |
| 12 | 213 | 60 | 40 | 0 | 0 | 0 | 0 | 3.0 | 2.0 | 5.0 | 202 | 0 | 0 | 0 | 0 | 202 | 100 |
| 14 | 187 | 59 | 41 | 0 | 0 | 0 | 0 | 3.7 | 5.0 | 8.7 | 171 | 3 | 2 | 0 | 0 | 168 | 98 |
| 16 | 203 | 47 | 33 | 20 | 0 | 0 | .2 | 2.3 | 20.0 | 22.5 | 157 | 0 | 0 | 19 | 12 | 138 | 88 |
| 18 | 391 | 43 | 34 | 23 | .2 | 1.5 | 1.2 | 1.5 | 6.0 | 10.4 | 350 | 14 | 4 | 18 | 5 | 318 | 91 |
| 20 | 451 | 43 | 32 | 25 | 0 | 4.5 | .3 | 1.0 | 11.0 | 16.8 | 375 | 15 | 4 | 60 | 16 | 300 | 80 |
| 22 | 612 | 42 | 33 | 25 | 0 | 4.5 | 0 | .8 | 12.0 | 17.3 | 506 | 15 | 3 | 71 | 14 | 420 | 83 |
| 24 | 576 | 41 | 33 | 26 | .2 | 5.8 | 0 | .3 | 10.0 | 16.3 | 482 | 10 | 2 | 29 | 6 | 443 | 92 |
| 26 | 374 | 40 | 33 | 27 | 0 | 7.0 | 0 | 0 | 8.0 | 15.0 | 318 | 16 | 5 | 41 | 13 | 261 | 82 |
| 28 | 441 | 39 | 33 | 28 | 0 | 9.3 | 0 | 0 | 18.0 | 27.3 | 321 | 0 | 0 | 39 | 12 | 282 | 88 |
| 30 | 136 | 38 | 34 | 28 | .6 | 5.5 | 0 | 0 | 0 | 6.1 | 128 | 0 | 0 | 22 | 17 | 106 | 83 |
| 32 | 59 | 38 | 33 | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 59 | 0 | 0 | 10 | 17 | 49 | 83 |
| 34 | 34 | 37 | 34 | 29 | 2.6 | 25.0 | 0 | 0 | 0 | 27.6 | 25 | 0 | 0 | 8 | 33 | 17 | 67 |
| 36 | 26 | 37 | 33 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 9 | 33 | 0 | 0 | 17 | 67 |
| 38 | 42 | 38 | 33 | 29 | 0 | 33.3 | 0 | 0 | 0 | 33.3 | 28 | 0 | 0 | 5 | 17 | 23 | 83 |
| All size classes | 3,745 | 43 | 34 | 23 | .1 | 4.9 | .2 | .9 | 9.8 | 15.9 | 3,148 | 82 | 3 | 322 | 10 | 2,744 | 87 |

[1] Basis: Myers (1963).
[2] Exclusive of volume reduction due to internal defect.
[3] Basis: nominal 8-foot veneer bolt length.
[4] Basis: veneer bolt quality classes assumed in the study.

ies have indicated that clear bolt faces, and particularly adjacent clear faces, are probably the best single indicator of veneer recovery potential. A significant quality grading system might then be based upon the occurrence and relative position of clear bolt faces. Accordingly, three veneer bolt quality classes based on these criteria were hypothesized for 8-foot veneer bolts:

Class 1--two or more adjacent clear bolt faces (8-foot half-faces).
Class 2--one clear bolt face, or two opposite clear bolt faces.
Class 3--no clear bolt faces.

Recorded stem quality data indicating the occurrence and position of 8-foot clear faces provide the means of segregating material into these quality classes. Net veneer log potential per acre, by bolt quality class and tree diameter class, is presented in table 4.

## Commercial Pole Potential

### Gross Pole Potential

Stems that meet pole specifications have a value as poles that far exceeds their value in alternative uses. Consequently, pole potential for the example stand was appraised carefully. Gross commercial pole potential for a stand is expressed in terms of stems per acre, rather than volumetric measurement. All stems 9.0 to 18.9 inches in diameter were initially considered potential poles. Gross pole potential by tree diameter class is indicated in table 5.

### Net Pole Potential

Due to the stringent specifications for commercial poles, a number of visible stem features render stems unsuitable: excessive knot size, excessive aggregations of knots, compression wood (lean), fork, crook, and major sweep. In general, poles with a single knot greater than 4 inches in diameter, or knots aggregating over 8 inches in diameter within a 1-foot stem section, are inadmissible. These limiting knot features were used in the field as an indication of maximum merchantable pole length. Only stems with an apparent merchantable pole height in feet of at least 2-1/2 times diameter in inches could be designated for further consideration. As shown in table 5, knot limitations eliminated all potential poles. The remaining limiting stem features, including fork, crook, major sweep, and lean of 5 degrees or more, were still evaluated, however, to complete the sample analysis of net pole potential. The additional reductions in net pole potential that would be imposed by these remaining limiting stem

Table 5.--Gross pole potential, reductions due to limiting features, and net potential, by tree diameter class

| D.b.h. class (Inches) | Gross poles per acre | Limiting stem features | | | | | Total reduction[5] | Net poles[6] per acre |
|---|---|---|---|---|---|---|---|---|
| | | Inadmissible knot features[1] | Fork | Crook[2] | Major sweep[3] | Lean[4] | | |
| | Number | Percent | | | | | | Number |
| 10 | 12.40 | 100 | 0 | 0 | 2 | 11 | 100 | 0 |
| 12 | 7.62 | 100 | 0 | 4 | 0 | 10 | 100 | 0 |
| 14 | 2.36 | 100 | 0 | 10 | 0 | 10 | 100 | 0 |
| 16 | 1.80 | 100 | 5 | 5 | 5 | 35 | 100 | 0 |
| 18 | 2.25 | 100 | 6 | 0 | 9 | 28 | 100 | 0 |
| Total | 26.43 | 100.0 | .9 | 2.4 | 2.0 | 13.7 | 100.0 | 0 |

[1] Knot features were considered inadmissible if a single 4-inch diameter knot, or knots aggregating 8 inches in diameter within a 1-foot stem section, limited merchantable length in feet to less than 2-1/2 times d.b.h. in inches.
[2] At least one-half mean diameter deviation in straightness within section 5 feet or less in length.
[3] At least one-third d.b.h. deviation in straightness.
[4] 5 degrees or more.
[5] Aggregate percent reductions in each diameter class will exceed 100 percent, due to multiple occurrence of limiting stem features.
[6] Exclusive of reductions due to internal defect.

features are also shown in table 5. It should be noted that aggregate reductions in all diameter classes exceed 100 percent due to the multiple occurrence of limiting features.

### Commercial Pole Quality Segregation

Quality standards for commercial poles are defined in specifications set forth by the American Standards Association (1963). Because of critical strength requirements, the quality standards are detailed and stringent. The pole potential of a stand is consequently quite easily overestimated. "Apparent" pole potential based upon stem size distribution is particularly misleading, as is demonstrated by the foregoing analysis of net potential. A valid appraisal requires knowledge of the frequency of occurrence of limiting stem features. The recorded stem quality data provide the means of making such an appraisal.

Once net pole potential is determined, the recorded information also provides a means of segregating by quality classes or potential value classes. Recognized classes of commercial poles are based upon pole length and diameter, both of which are known from inventory data. For timber stands in which a net pole potential is found, this potential can be expressed in terms of commercial pole class distribution. Again, for particular applications, a less detailed quality stratification may be more desirable, such as height classes of "under 40 feet" and "over 40 feet." This also is readily obtained from inventory data.

Potential pole stems may find use in construction, as well as for transmission poles. Pole frame construction accounts for a considerable proportion of the market for shorter poles. Standard specifications, other than those developed to meet particular design requirements, do not exist for construction poles. The Forest Products Laboratory has recommended, however, that poles used for framing meet American Standard or equivalent grades (Wood 1957). Because poles commonly used in construction are shorter than transmission poles, the minimum height-diameter ratio relationship of 2-1/2 times diameter can be reduced substantially. It should be noted, however, that inventory data do provide for appraising pole potential by any specific quality criteria judged suitable for the end use in mind.

## Pulpwood Potential

### Gross Volume Determination

Depending upon demand for pulpwood and the nature of future multiproduct logging operations, virtually all of the timber considered might be utilized as pulp. Consequently, all timber 7.0 inches and larger in diameter was considered potential pulpwood. Since the inventory data provide volume in-

formation by tree diameter classes, the volume in any range of diameter classes under consideration is immediately available. Gross pulpwood volumes were obtained by applying localized cubic-foot volume tables (Myers 1963) to stand measurement data. Gross pulpwood volume, by tree diameter class, is indicated in table 6.

## Net Volume Determination

Most visible stem quality features will not significantly affect volume of usable pulpwood. Fire scar, however, will affect net volume both as an absolute reduction of volume and as a source of charred, unsuitable material. Because charred wood must be excluded from pulping operations, fire scarred trees probably will be long-butted above the scar. Consequently, a cubic-foot volume deduction equivalent to the lower 4 feet of the merchantable stem was adopted. Lightning scars of the type recorded are similarly often accompanied by charred wood, pitch streaks, and ingrown callus bark. Stems with lightning scar were therefore considered unsuitable for pulp, and were culled from gross scale. These scale deduction factors were applied to the proportion of the stand affected by fire and lightning scar. Resulting scale deductions and net pulpwood volumes, by tree diameter class, are shown in table 6.

Table 6.--Gross pulpwood volume,[1] deduction due to defect, and net volume,[2] by tree diameter class

| D.b.h. class (Inches) | Gross volume per acre | Defect type | | Total defect | Net volume per acre |
|---|---|---|---|---|---|
| | | Lightning scar | Fire scar | | |
| | Cu. ft. | - - - Percent - - - | | | Cu. ft. |
| 8 | 94 | 0 | 0 | 0 | 94 |
| 10 | 87 | 0 | 0 | 0 | 87 |
| 12 | 66 | 0 | 0 | 0 | 66 |
| 14 | 51 | 0 | 0 | 0 | 51 |
| 16 | 50 | 0 | 0 | 0 | 50 |
| 18 | 89 | 3 | .6 | 3.6 | 86 |
| 20 | 96 | 11 | .6 | 11.6 | 85 |
| 22 | 118 | 12 | .5 | 12.5 | 103 |
| 24 | 104 | 13 | .4 | 13.4 | 90 |
| 26 | 67 | 16 | 0 | 16.0 | 56 |
| 28 | 74 | 28 | 0 | 28.0 | 53 |
| 30 | 22 | 11 | 1.9 | 12.9 | 19 |
| 32 | 9 | 0 | 0 | 0 | 9 |
| 34 | 5 | 50 | 10.2 | 60.2 | 2 |
| 36 | 4 | 0 | 0 | 0 | 4 |
| 38 | 6 | 67 | 11.0 | 78.0 | 1 |
| All size classes | 942 | 8.6 | .4 | 9.0 | 856 |

[1] Basis: Myers (1963).
[2] Exclusive of volume deduction due to internal defect.

## Pulpwood Quality Segregation

Specific, well-defined quality criteria have not been developed for raw pulpwood. Certain quality specifications are often used by pulpmills, however, in defining the type of material they are willing to accept. It seems probable that, in the future, more attention will be given to defining quality classes for such material. It is not difficult to visualize stem characteristics that might reduce its suitability for pulpwood. For example, severe crook, sweep, or fork may make handling difficult, reduce the solid wood volume of a load, and interfere with debarking or mechanical grinding. Compression wood, indicated by lean, may significantly reduce pulp yields. The cellulose content of severe compression wood has been found to be as much as 50 percent below normal (Hale et al. 1961). Excessive numbers of large knots may reduce suitability of pulpwood for grinding and reduce value for chemical pulping. Pulpwood quality classes based upon these or other stem characteristics can readily be established from stem quality inventory data. The ability to stratify pulpwood into such quality classes is important in appraising suitability for specific pulping processes and handling methods.

## Application To Additional Products

The preceding examples of how to appraise stand product potential by using inventory data are by no means exhaustive. Changes in utilization patterns and consumer demands may focus attention on other, perhaps newly developed products. As additional products become of interest, the appropriate stand volumes and quality criteria can be selected from existing inventory data to estimate stand potential.

Raw material quality standards also change with time. New quality standards are developed to meet the needs of new products, and existing standards are revised. Most such standards will incorporate as primary grading

unduly restrict the utilization potential for specific products, and the frequency with which they occur in the stand. He needs to know how much the utilization potential for specific products is affected by stem size distribution. With this type of stand information, timber managers have a basis for making management decisions. They can adequately assess the effect of a given stand treatment upon present and future product potential.

Detailed inventory knowledge of the timber resource and its potential is also indispensable to the wood industry, and to those concerned with guiding industrial development. Optimum utilization of timber has long been hampered by inadequate characterization of the raw material. Inventory information forms a reliable basis for interproduct comparisons in determining optimum use of the resource.

An analysis of multiproduct potential on the study area was presented in a preceding section. The information developed can be aggregated and summarized in the manner shown in table 7. Two examples will perhaps show how to apply such information.

In the locale represented by the study area, widespread interest has been shown in the development of a plywood industry. Existing criteria some of the stem quality features described by inventory data. Stand potential for the particular product can be appraised or reappraised in terms of these new quality standards by selecting and applying appropriate stem quality information. The inventory system thereby provides a high degree of flexibility for future product quality appraisal needs.

## MULTIPRODUCT INVENTORY INFORMATION AS A BASIS FOR DECISION

A multiproduct inventory system provides a wealth of information for both stand management and utilization planning. A primary objective of timber management is to produce salable raw material, within the restrictions imposed by other forest uses. A primary objective of timber utilization is to make the best use of the resource, within existing technology and produce demands. Both objectives require knowledge of the physical characteristics of the stand, and the effect of these characteristics upon product yield and quality. A multiproduct inventory system can provide such information.

The timber manager needs to know which products the stand can and should be directed toward. He needs to know which stem features

Table 7.--Net product potential per acre, by diameter class, on the study area

| D.b.h. class (Inches) | Net saw log volume by log grade | | Net veneer log volume by bolt quality class | | | Net pole potential by height class | | | Net pulpwood volume |
|---|---|---|---|---|---|---|---|---|---|
| | 3 & Better | 4 - 5 | 1 | 2 | 3 | 20-30 ft. | 30-40 ft. | 40 ft. & over | |
| | Bd. ft. per acre | | Bd. ft. per acre | | | Number per acre | | | Cu. ft. per acre |
| 8 | -- | -- | -- | -- | -- | -- | -- | -- | 94 |
| 10 | -- | -- | -- | -- | -- | 0 | 0 | 0 | 87 |
| 12 | 4 | 196 | 0 | 0 | 202 | 0 | 0 | 0 | 66 |
| 14 | 9 | 164 | 3 | 0 | 168 | 0 | 0 | 0 | 51 |
| 16 | 26 | 163 | 0 | 19 | 138 | 0 | 0 | 0 | 50 |
| 18 | 24 | 322 | 14 | 18 | 318 | 0 | 0 | 0 | 86 |
| 20 | 84 | 335 | 15 | 60 | 300 | -- | -- | -- | 85 |
| 22 | 103 | 469 | 15 | 71 | 420 | -- | -- | -- | 103 |
| 24 | 64 | 468 | 10 | 29 | 443 | -- | -- | -- | 90 |
| 26 | 57 | 277 | 16 | 41 | 261 | -- | -- | -- | 56 |
| 28 | 46 | 337 | 0 | 39 | 282 | -- | -- | -- | 53 |
| 30 | 27 | 98 | 0 | 22 | 106 | -- | -- | -- | 19 |
| 32 | 19 | 40 | 0 | 10 | 49 | -- | -- | -- | 9 |
| 34 | 17 | 8 | 0 | 8 | 17 | -- | -- | -- | 2 |
| 36 | 17 | 9 | 9 | 0 | 17 | -- | -- | -- | 4 |
| 38 | 19 | 9 | 0 | 5 | 23 | -- | -- | -- | 1 |
| Total per acre | 516 | 2,895 | 82 | 322 | 2,744 | 0 | 0 | 0 | 856 |

*Figure 17.--Poor pruning characteristics can severely limit commercial pole potential.*

timber quality information is not entirely adequate, however, for an appraisal of veneer potential. The net quantity and quality of potential veneer log material in the stand is shown in table 7. In addition, inventory information shows that the greatest quality (and quantity) potential exists in timber 18 through 26 inches in diameter. The effect of removal of given diameter class trees upon overall quality distribution can also be ascertained. Such an appraisal of potential provides industry with an adequate basis for making decisions and for production planning.

By referring to stem quality data for features affecting veneer potential (see table 4), it is apparent that excessive lean significantly reduces net potential. Management and cutting practices designed to reduce the incidence of lean may, in the long run, increase net veneer potential as much as 10 percent.

Commercial poles enjoy a relatively high value, compared to alternative primary products; consequently, pole potential is worth careful consideration. On the basis of diameter and height class distribution alone, a commercial pole potential could be assumed to exist in the stand. The stem quality information provided by the inventory system shows that this initial assumption is quite misleading, however. No pole potential exists in any pole height class in the study area. For current utilization planning, this alternative is removed from further consideration.

Reference to table 5 indicates that knots or limbs, crook, and lean (compression wood) are the primary stem features limiting pole potential. Knots or limbs exceeding allowable limits are by far the most important limiting factor (fig. 17). Stand management practices designed to accelerate natural pruning and height growth, or artificial pruning of potential pole stems, may in time develop a net pole potential in the stand. If such practices are not considered feasible, stand management should be directed toward other products. Future potential for poles will probably remain quite low.

These brief examples illustrate how multiproduct inventory information applied on a broader scale, such as for a compartmentized working circle, can be used to reach meaningful utilization and stand management decisions.

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1965. A method of evaluating multiproduct potential in standing timber. U. S. Forest Serv. Res. Paper RM-15, 24 pp., illus. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Method described will: (1) remove observer bias from stand quality inventory; (2) provide a record of frequency of occurrence of stem features that affect product quality and yield; (3) characterize and quantify suitability of the timber resource for a broad range of products; (4) provide adequate multiproduct quality and yield information for management and utilization decisions; and (5) provide a continuing basis for such decisions through time.

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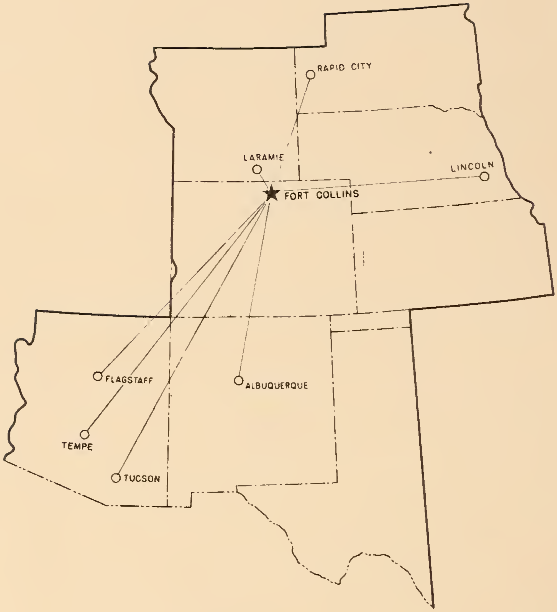
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